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Hoverfly communities on former agricultural fields: a study of afforestation and planted forests stands in the Voeren region

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Abstract

In the Voeren region the hoverfly communities of two ancient forests were compared with the communities of three plantations and six afforestation sites on former agricultural fields with different age, management and history. 92 hoverfly species were collected, most of them with Malaise traps. Observed diversity and community composition depends on age, history, management and type of forest expansion. In the beginning (after 7 years forest succession), afforestation on former agricultural fields results in a greater diversity. Probably the open character and mosaic patron encouraged by spontaneous afforestation, results in a temporary greater diversity than observed in the planted and ancient forests. Along with further development towards older forest age, the diversity decreases and a more stable hoverfly community is observed. Typical ancient forest species were only collected in the ancient forests where they represent the greatest amount of the hoverfly community. We assume that it takes very long before a typical ancient forest hoverfly community has settled in afforestation sites and new planted forests on formerly agricultural fields. Even after 25 years of spontaneous forest succession or 20 years after plantation, we did not observe typical ancient forest species.

Key words: Syrphidae, afforestation, diversity, forest age, community analyses, Belgium.

Introduction

Examples of evaluation of forest management types on former agricultural by different entomofauna groups are scarce. The use and info that hoverflies could provide in such studies is supposed to be limited. Nevertheless forests have different layers of vegetation (moss, herb, shrub and trees) and so they provide diverse habitats for hoverflies. In addition they are accommodated with varying light, different shade conditions and plenty of dead organic material. Dead wood and fallen leaves are food for some of the hoverfly larvae (VAN DER GOOT, 1981; VERLINDEN & DECLEER, 1987; VERLINDEN, 1991; VAN VEEN, 2004). In general all of the hoverfly species whose larvae feed on decaying wood are typically seen as woodland species (VAN VEEN, 2004). In the present study, the hoverfly communities of 11 forests in the Voeren region were studied. The aim of the inventory was to investigate the effect of forest developmental stage on the hoverfly communities. Additionally we will also try to compare and explain hoverfly diversity in afforestation sites and planted forest stands with the fauna from the adjacent ancient forest sites.

Material en methods

Study area

The oldest sites in Flanders where afforestation was planned and carried out on formerly arable fields and grasslands on loamy soils are situated in the "Voeren" region, an area on the extreme eastern border of Flanders, neighbouring Germany. In the neighbourhood of two forest relicts (the "Altenbroek" and the "Alserbos"), large areas were predestined for afforestation or to be altered to forest by plantation of indigenous trees (DEKONINCK *et al.*, 2005). These changes took place in small-scale plots where different types of trees were planted and some fields spontaneously afforested. At present, these two forests consist of small forest plots with different age, structure and history and as such are ideal to evaluate current ongoing afforestation. Hoverflies were sampled in five sites in the "Altenbroek" and six sites in the "Alserbos". Characteristics of the sampled sites are given in Table 1.

Sampling

In each site three pitfalls, three white water traps and one Malaise trap were installed. All pitfall (diameter of 9.5 cm) and white water traps (17x10 cm and 5 cm high) were placed in a row, spaced 3-5 m apart. A 3.5% formaldehyde solution was used for killing and fixation and some detergent was added to lower surface tension. All traps were emptied 12 times from 02-IV-2003 until 08-X-2003 (exact data: 17-IV, 01-V, 14-V, 30-V, 14-VI, 26-VI, 11-VII, 25-VII, 07-VIII, 22-VIII, 19-IX and 08-X). Each Malaise trap collecting vial was filled with a 75% alcohol solution.

Shannon's diversity index

The Shannon's diversity index is a mathematical measure of species diversity which provides more information about community composition than simply species richness (i.e. the number of species present). It also takes the relative abundances of different species into account.

Table 1 — Code, history, description and age of the sampled sites.

Site code	Forest	History	Description of the site	Forested since
Site 1	Altenbroek	Ancient forest	Old oak-birch forest	<1775 de Ferraris
Site 2	Altenbroek	Arable field	Afforestation and extensive grazing (Galloways), *Salix* sp. and birch.	1996
Site 3	Altenbroek	Grassland	Afforestation and extensive grazing (Galloways), no shrubs or trees	1996
Site 4	Altenbroek	Arable field	Afforestation and intensive summer grazing, *Salix* sp. and birch	1996
Site 5	Altenbroek	Arable field	Plantation of *Quercus robur*	1989
Site 6	Alserbos	Ancient forest	Old oak-birch forest	<1775 de Ferraris
Site 7	Alserbos	Grassland	Afforestation of birch	1980
Site 8	Alserbos	Arable field	Afforestation of birch	1980
Site 9	Alserbos	Grassland	Plantation of *Prunus avium* with fragments of *Calluna vulgaris*	1985-1990
Site 10	Alserbos	Arable field	Afforestation of birch	1980
Site 11	Alserbos	Grassland	Plantation of *Quercus robur*	1985-1990

This index can be calculated as:

$$H= - \sum (P_i * \ln P_i)$$

with P_i the proportion of species i relative to the total number of species.

DCA community-analysis

Detrended Correspondence Analysis was used to compare sites with respect to overall species composition. DCA is a multivariate technique that positions samples along orthogonal axes that sequentially explain the greatest amount of inter-sample variation. Default settings were used, i.e. detrending by 26 segments and non-linear rescaling. Only species from which more than 15 specimens were collected were used for the analyses.

Results

General results

In total 92 species of hoverflies were collected and 1995 specimens were identified using VAN VEEN (2004). The species and numbers collected in each site are presented in Table 2. In sites 02, 03 and 04 we collected more than 300 specimens and respectively 48, 40 and 41 species. Five species were found in all sites: *Episyrphus balteatus* (DEGEER, 1776), *Platycheirus albimanus* (FABRICIUS, 1781), *Rhingia campestris* MEIGEN, 1822, *Dasysyrphus venustus* (MEIGEN, 1822), and *Melanostoma scalare* (FABRICIUS, 1794). About 78% of all specimens were collected with Malaise traps (n=1550). In pitfall traps (6%) and white water traps (16%) only few hoverflies were found.

Four very rare and exceptional hoverflies were collected. *Callicera rufa* SCHUMMEL, 1842 is a very rare species in the Benelux. In the Netherlands it is only known from pine-forest (NJN, 1998; REEMER, 2000). VERLINDEN (1991) mentions only one record in Belgium from the Lesse-valley. A second rare species *Epistrophe diaphana* (ZETTERSTEDT, 1843) is a thermophylic hoverfly from forest edges and open spots in large forests (VERINDEN, 1991; NJN, 1998). This common southern species is only found during hot summers in the Netherlands (NJN, 1998). The uncommon *Epistrophe flava* DOCZKAL & SCHMID, 1994 is a species which is known in the Netherlands, Germany and Denmark from ancient deciduous forests (NJN, 1998; REEMER, 1999; 2000). A fourth remarkable record is *Melangyna barbifrons* (FALLÉN, 1817), a spring species visiting *Salix* sp. (NJN, 1998).

Diversity

The total number of species was highest in the three young spontaneous forest stands (Site 2, 3 and 4). Besides in both forests we found less species in the planted sites than in the spontaneous forests. We have the impression that afforestation results in more divers and extensive hoverfly communities. The history seems less important: former grasslands which have the same age and type of forest expansion do not result in totally different fauna than in similar arable fields abandoned at the same time.

The average Shannon's diversity index (see Table 3) is higher in the "Altenbroek" forest (H=2.87±0.19 and "Alserbos" forest: H=2.58±0.41). Both reference sites had a rather similar H although in the reference of the "Altenbroek" forest only 21 species were found (reference "Alserbos" forest 33 species). Site 3 (recent afforestation on former grassland) had a rather low Shannon's diversity index although we found 40 different species.

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Habitat preference

Frequently high diversity is a measure for high nature value in a particular site. This is not always the case. Sometimes small sites can yield a high diversity which is a result of a great amount of "not-site characteristic" species as temporary species and species that are passing by. Sometimes also the proportion of eurytope species is higher. When making an evaluation from a type of management on a site besides diversity it is better to also take into account the habitat preferences and overall changes in species richness and amounts from of all found species. Also the number of individuals from the different habitat preference groups should be studied.

An unambiguous habitat preference could not be not be generated for each species. A lot of species are not restricted to one type of the habitats here considered. From some of them the habitat of the larvae is different than that of the adults (SSYMANK, 2001). We gave habitat preferences base upon VERLINDEN (1991), NJN (1998), REEMER (2000), SPEIGTH *et al.* (2003) and our own experience and we distinguished six categories: eurytope species, species from open sites, species from forest edges and common and rare forest species. All species which could not be placed in one of these groups were catalogued in the sixth group called "others" (see Fig. 1).

After dividing all sites in four groups (young spontaneous, old spontaneous, ancient forest and plantations) we can check if we find significant differences in numbers of the 6 categories. The contribution of eurytopic species is significantly higher in the young spontaneous forests than in the older spontaneous forests (Mann-Withney U-test, Z=1.99, p=0.046) and than in the plantations (Mann-Withney U-test, Z=1.96 en p =0.046).

In the ancient forests the contribution of the number of forest species (common and rare) was highest and eurytopic species or species belonging to the group "others" were almost absent.

In the younger forest sites of the "Altenbroek", the part eurytopic species and species from open sites is greater than percentage of forests species. The contribution of forest species in the plantations (site 5 and 11) was higher than in most of the other sites. The average number of eurytopic species was higher in the "Altenbroek" (n=12.8±4.55 and "Alserbos" n=9.17±1.83). Together with ongoing forest succession the number of eurytopic species decreases and the contribution of forest species becomes higher.

Larval feeding mode

We classified the species according to larval feeding mode to see if in the older forests relatively more critical species (those depending on dead wood i.e. sapoxylic

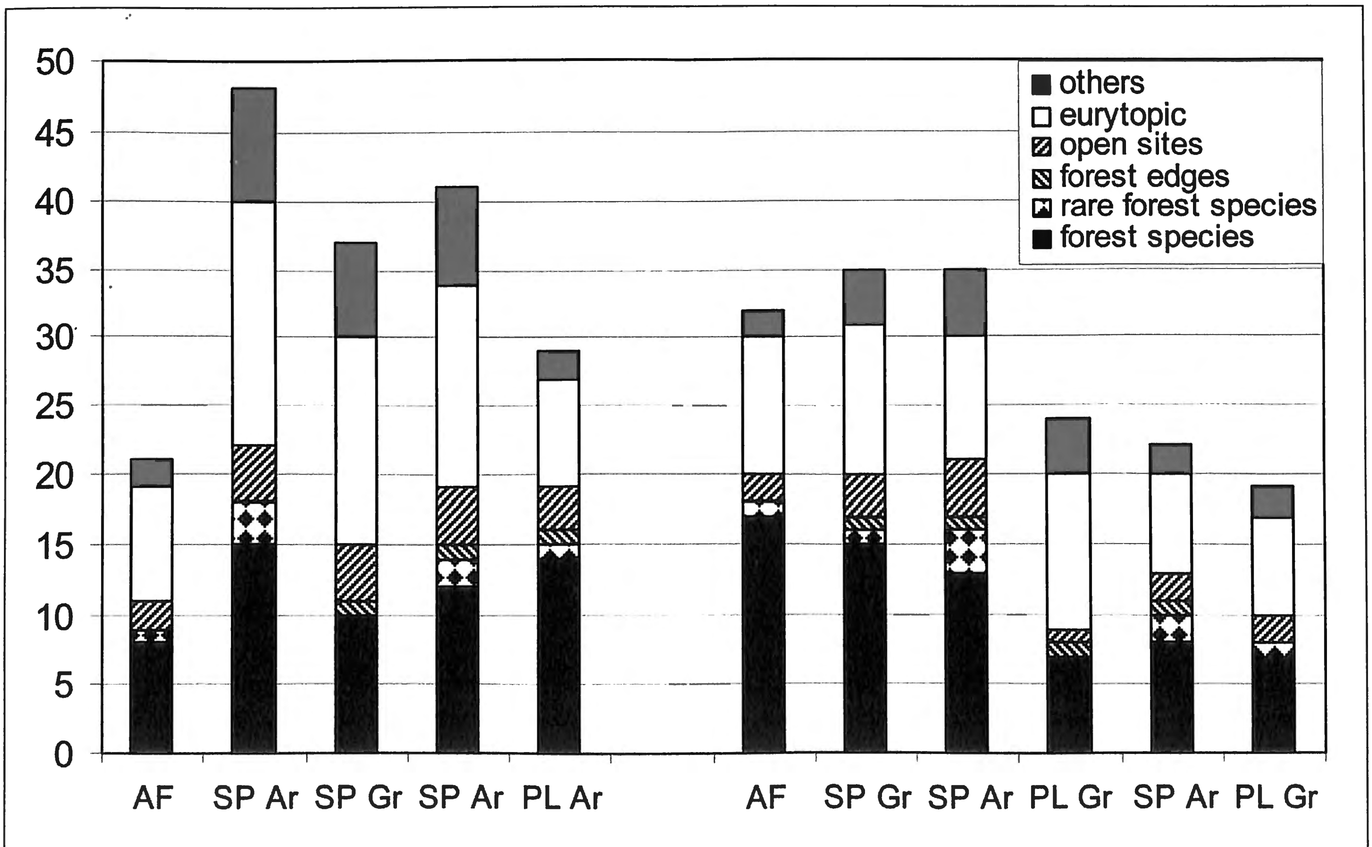

Fig. 1 — Habitat preference of all found species in each site with SP=afforestation site, spontaneous forest, PL=planted forest, Gr=former grassland, Ar=former arable field and AF=ancient forest (reference) (Altenbroek left and Alserbos right).

Table 2 — Species and number of individuals collected in each site. SP=afforestation site, spontaneous forest, PL=planted forest, Gr=former grassland, Ar=former arable field and AF=ancient forest (reference).

Species	**Code cf. NJN, 1998 and http:// www.syrphidae.com**	**Altenbroek**					**Alserbos**					
		Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 07	Site 08	Site 09	Site 10	Site 11
		AF	SP Ar	SP Gr	SP Ar	PL Ar	AF	SP Gr	SP Ar	PL Gr	SP Ar	PL Gr
Baccha elongata	*BACHELON*	2			1	9	12	9	25	2		33
Brachypalpoides lentus	*BRPOLENT*						3				1	
Brachypalpus laphriformis	*BRPULAPH*	2	2	1	2	6	3	2	1		1	1
Caliprobola speciosa	*CALPSPEC*				1	1						
Callicera rufa	*CALLRUFA*			1								
Chalcosyrphus nemorum	*CHALNEMO*		1				3	1	1			
Cheilosia albipila	*CHILALBP*		1	2	2							
Cheilosia albitarsis	*CHILALTS*			13								
Cheilosia chloris	*CHILCHLO*								1			
Cheilosia lenis	*CHILLENI*								1		2	
Cheilosia pagana	*CHILPAGA*	1		1		2		1	9			2
Cheilosia proxima	*CHILPROX*			1								
Chrysotoxum bicinctum	*CHYTBICI*			1	8		2	1	1			
Chrysotoxum cautum	*CHYTCAUT*			2					4	3	1	
Criorhina asilica	*CRIOASIL*				1		2			1		
Criorhina berberina	*CRIOBERB*	4	2				10	1	2			
Criorhina floccosa	*CRIOFLOC*						2					
Criorhina ranunculi	*CRIORANU*	1					3					1
Dasysyrphus albostriatus	*DASSALBO*	1	5		1		6	4			1	
Dasysyrphus hilaris	*DASSHILA*		2		1			1		1		
Dasysyrphus tricinctus	*DASSTRIC*							2	3			
Dasysyrphus venustus	*DASSVENU*	2	2	2	4	4	13	13	12	8	7	4
Didea alneti	*DIDEALNE*		1									
Didea fasciata	*DIDEFASC*					1						
Didea intermedia	*DIDEINTE*		1									
Epistrophe diaphana	*EPSTDIAP*			1								
Epistrophe eligans	*EPSTELIG*	1	2		1	1	1	1		1		
Epistrophe euchroma= Meligramma euchroma	*EPSTEUCH MELIEUCH*				1							
Epistrophe flava	*EPSTFLAV*						1			1	1	
Epistrophe melanostoma	*EPSTMELA*			2								
Epistrophe nitidicollis	*EPSTNITI*	2	3	4	1			1				
Episyrphus auricollis= Meliscaeva auricollis	*EPYSAURI= MLSCIAUR*					1	1					
Episyrphus balteatus	*EPYSBALT*	3	53	20	20	5	33	21	31	7	7	2
Episyrphus cinctellus= Meliscaeva cinctella	*MLSCCINC= EPYSCINC*								2			
Eristalis arbustorum	*ERISARBU*		1									
Eristalis interrupta= Eristalis nemorum	*ERISINTE = ERISNEMO*		1	4								
Eristalis lineata= Eristalis horticola	*ERISLINE ERISHORT*				1							
Eristalis pertinax	*ERISPERT*		2	2	3	2	2		2	1	3	1
Eristalis tenax	*ERISTENA*		14	31	9		1	1	1	1		
Eumerus spec.	*EUME sp.*					1						
Eupeodes corollae	*EUPECORO*	1	9	20	4					2		
Eupeodes latifasciatus	*EUPELAFA*	1	22	115	24	1		3	1	3	1	
Eupeodes luniger	*EUPELUNI*		5	6	4		3	6	4		1	2
Eupeodes nielseni	*EUPENIEL*		1									
Eupeodes nitens	*EUPENITE*						1	1				
Eupeodus bucculatus= Eupeodes latilunulatus	*EUPEBUCC= EUPELALU*		3		3	9		2	2			

Species	Code cf. NJN, 1998 and http:// www.syrphidae.com	Altenbroek					Alserbos					
		Site 01	Site 02	Site 03	Site 04	Site 05	Site 06	Site 07	Site 08	Site 09	Site 10	Site 11
		AF	SP Ar	SP Gr	SP Ar	PL Ar	AF	SP Gr	SP Ar	PL Gr	SP Ar	PL Gr
Ferdinandea cuprea	*FERDCUPR*	4				8	3	1	1		2	
Helophilus hybridus	*HELOHYBR*				1				1			
Helophilus pendulus	*HELOPEND*		26	7	11	2	5	8	15	4	6	6
Helophilus trivittatus	*HELOTRIV*		2									
Heringia sp.= Neocnemodon sp.	*HERIsp.= NEOCsp.*				2			1				
Leucozona lucorum	*LEUCLUCO*		2			1						
Melangyna barbifrons	*MELGBARB*							1				
Melangyna cincta	*MELGCINC*		1						1		2	1
Melangyna lasiophthalma	*MELGLASI*	2	2			1		4			3	4
Melangyna triangulifera	*MELGTRIA*		1	1			1		2			1
Melangyna umbellatarum	*MELGUMBE*						2					
Melanostoma mellinum	*MELAMELL*		1	18	21	1		1	1			
Melanostoma scalare	*MELASCAL*	3	8	2	5	4	6	10	7	7	6	5
Merodon equestris	*MEROEQUE*		1									
Myathropa florea	*MYATFLOR*		3		1	2	1	1				1
Neoascia podagrica	*NEOAPODA*		1							1		
Orthonevra brevicornis	*ORTHBREV*					1						
Paragus haemorrhous	*PARGHAEM*				3							
Parasyrphus punctulatus	*PARSPUNC*			1		1		3				
Pipiza austriaca	*PIPZAUST*				1		1					
Pipiza bimaculata	*PIPZBIMA*							1				
Pipiza fenestrata	*PIPZFENE*									1		
Pipiza noctiluca	*PIPZNOCT*		2						1			
Platycheirus albimanus	*PLATALBI*	7	25	7	37	4	18	30	30	23	8	5
Platycheirus angustatus	*PLATANGU*		3	9	6							
Platycheirus peltatus	*PLATPELT*		2	4	3							1
Platycheirus scambus	*PLATSCAM*			1								
Platycheirus scutatus	*PLATSCUT*	1	2	1				1	2	1		
Pyrophaena granditarsa	*PYROGRAN*		2	1								
Pyrophaena rosarum	*PYROROSA*		16	9	1							
Rhingia campestris	*RHINCAMP*	1	20	15	27	6	9	10	23	15	6	2
Scaeva pyrastri	*SCAEPYRA*			4								1
Scaeva selenitica	*SCAESELE*			1								
Sericomyia silentis	*SERISILE*								1			
Sphaerophoria scripta	*SPHASCRI*		41	78	77					3		
Syritta pipiens	*SYRIPIPI*		3		1					1		
Syrphus ribesii	*SYRPRIBE*	1	16	4	6	2	8	14	13	1	2	
Syrphus torvus	*SYRPTORV*		1				1	2	1		1	
Syrphus vitripennis	*SYRPVITR*	1	2	2	2	1	3	1		1	1	
Temnostoma bombylans	*TEMNBOMB*							1	6			
Temnostoma vespiforme	*TEMNVESP*						3			1		
Volucella bombylans	*VOLUBOMB*		1						1		2	
Volucella pellucens	*VOLUPELL*				3	1						
Xanthogramma pedissequum	*XAGRPEDI*			2	1					1		
Xylota segnis	*XYLOSEGN*	1	3	1	6	4	1	1	7		1	7
Xylota sylvarum	*XYLOSYLV*		1	2	2	2						
Total number of individuals		42	321	399	309	84	164	162	216	91	66	80
Total number of species		21	48	40	41	29	33	36	35	25	23	19

Table 3 — Number of species and Shannon's diversity index form each site with SP=afforestation site, spontaneous forest, PL=planted forest, Gr=former grassland, Ar=former arable field and AF=ancient forest (reference).

	Altenbroek					Alserbos					
	Site1	Site2	Site3	Site4	Site5	Site6	Site7	Site8	Site9	Site10	Site11
	AF	SP Ar	SP Gr	SP Ar	PL Ar	AF	SP Gr	SP Ar	PL Gr	SP Ar	PL Gr
Number of species	21	48	40	41	29	33	36	35	25	23	19
Shannon's diversity index	2.827	3.051	2.592	2.820	3.047	2.948	2.910	2.851	2.590	1.955	2.226

species) and relatively less broad species appeared (see Fig. 2). According to REEMER (2003) we could distinguish 4 larval feeding modes: saproxylic larvae (SA), carnivorous larvae (CA), phytophagous larvae and aquatic larvae (AQ). For some species an ambiguous larval feeding mode could not be given (?).

When we classify the species according to larval feeding method and we consider the amount of saproxylic species we can conclude that ancient forests indeed have a bigger part of saproxylic larval feeding hoverflies.

Hoverfly communities

The DCA-diagram (axis 1 and 2) is presented in Fig. 3. The first two axes accounted for the greatest part to the total variance explained by the species correspondence analysis. The axes of the DCA gave eigenvalues of λ=0.52 (axis1) and λ=0.15 (axis2). Eigenvalues of higher axes were lower than 0.05 and these axes were ignored due to their small contribution to the entire model. The DCA diagram suggests two clusters of species and sites. The first group (group A) contains the two reference sites and the plantation in the "Altenbroek". In this group we have mainly forest species. This hoverfly fauna is totally different from group B. This group unites three young forest stands from the "Altenbroek" where the fauna mainly consists of eurytopic species and species from open sites and grasslands.

Six species are positive correlated with the first axis (represented in bold in Table 4). They are all eurytopic species and species from open sites. The major important component which seems to determinate the hoverfly faunas is the closed versus open gradient from the sites. A further division in the closed sites is visualized along the second axis. *Baccha elongata* is significant positive correlated with this axis.

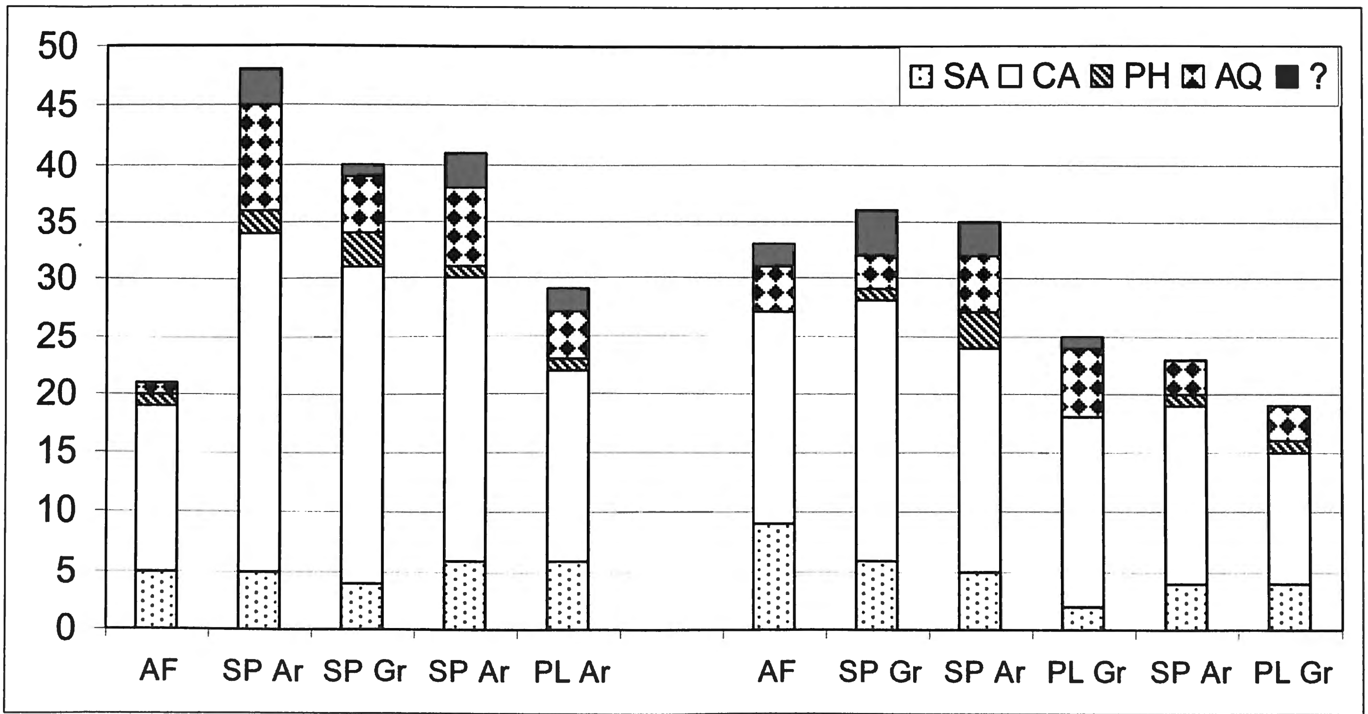

Fig. 2 — Larval feeding mode of all found species in each site with SP=afforestation site, spontaneous forest, PL=planted forest, Gr=former grassland, Ar=former arable field and AF=ancient forest (reference) and SA=saproxylic larval feeding mode, CA=carnivorous larval feeding mode (=predacious), PH=phytophagous larval feeding mode, AQ=aquatic larvae and ? = not known (Altenbroek left and Alserbos right).

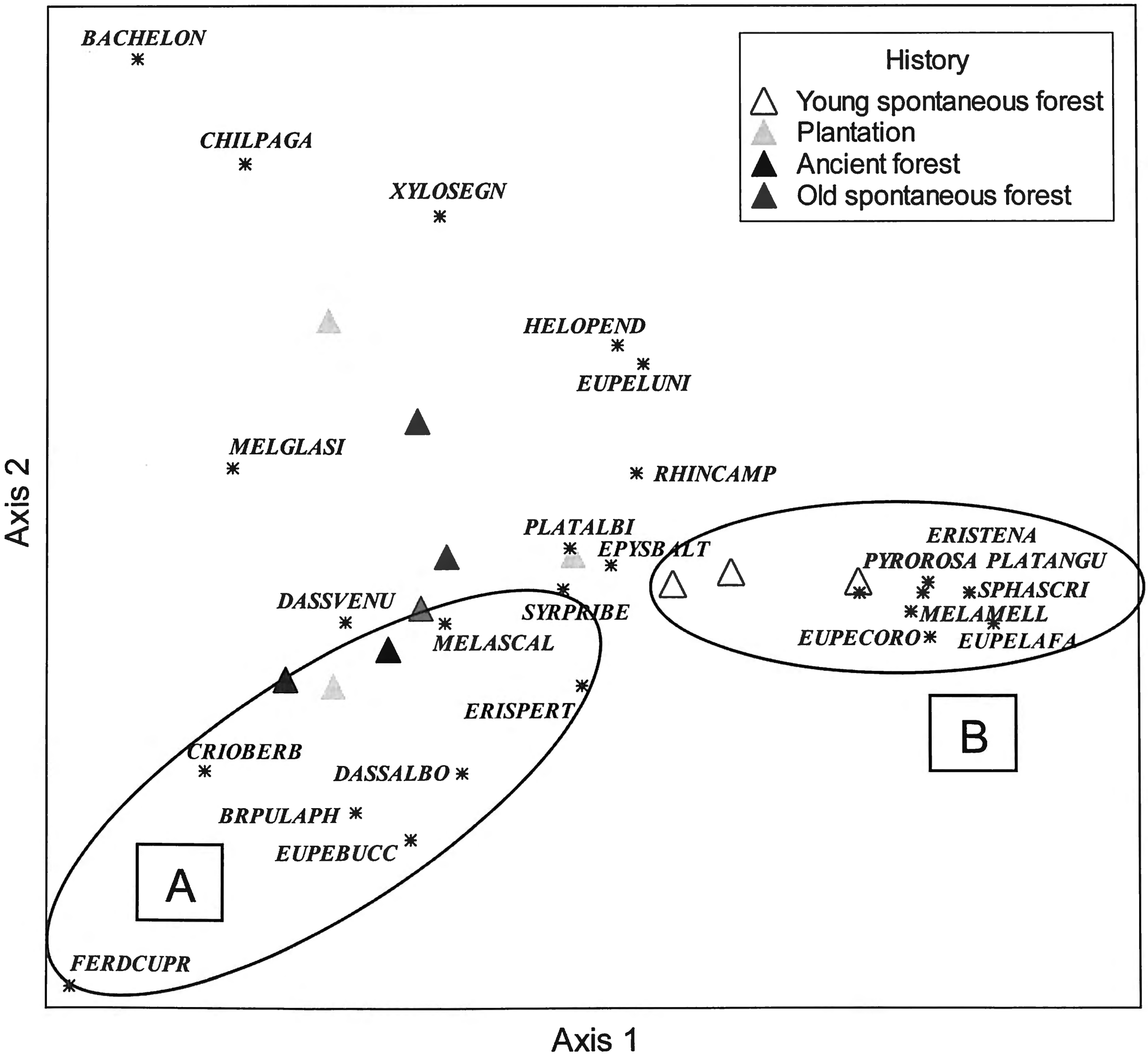

Fig. 3 — DCA diagram (axis 1 λ=0.53 and axis 2 λ=0.15) of sampled sites (axis 1 and 2) based on collected individuals for n = 11 sites and 25 species. Sites are presented by ▲ and their history, and species are listed by the first 4 letters of genus and species name.

Conclusions and discussion

The "Voeren"-region seems to be a faunistically very interesting region for hoverflies in Flanders. During this project some rare and very rare species in Flanders and Belgium were collected.

We found a higher diversity in the young afforestation sites from the "Altenbroek". Those sites are in fact still very open and so far only very poorly afforestated (afforestation since 1996). The open character of these sites probably encourages migrants, pioneer species and eurytopic species to establish a temporary population. We have the impression that where former arable fields evolve spontaneously towards forests the total diversity is higher. Their history i.e. whether they were grassland or arable field, is less important to make an evaluation of ongoing afforestation. The possibilities to visit a wide offer of nectar-providing flowers after a couple of years of forest succession seem very important. We found high coverage of herbs in young forest stand on both formerly grasslands and arable field.

There seems to be a significant increase in the similarity of invertebrate communities between restored and reference sites as time-since-afforestation and time-since-plantation increase. The amount of eurytopic species and species from open sites decreases and the amount of forest species increase. Also the total diversity decreases with increasing forest developmental stage.

Table 4 — Correlations of all hoverfly species with the first two axes, with significant correlations presented in bold (N= 11; Pearson r>0.73 for p<0.01; Kendall tau>0.60 for p<0.01).

Axis:	1			2		
	r	r-sq	tau	r	r-sq	tau
BACHELON	-.514	.264	-.496	**.778**	**.605**	**.305**
BRPULAPH	-.324	.105	-.226	-.536	.287	-.555
CHILPAGA	-.257	.066	-.316	.499	.249	.147
CRIOBERB	-.313	.098	-.281	-.316	.100	-.194
DASSALBO	-.003	.000	.042	-.301	.090	-.291
DASSVENU	-.316	.100	-.078	.142	.020	.195
EPYSBALT	.423	.179	.352	-.020	.000	.056
ERISPERT	.402	.162	.375	-.084	.007	-.125
ERISTENA	**.867**	**.752**	**.761**	-.075	.006	.103
EUPEBUCC	-.094	.009	.175	-.294	.086	-.131
EUPECORO	**.840**	**.705**	**.554**	-.094	.009	-.043
EUPELAFA	**.796**	**.634**	**.806**	-.071	.005	.020
EUPELUNI	.604	.364	.496	.231	.053	.267
FERDCUPR	-.590	.348	-.610	-.596	.355	-.610
HELOPEND	.459	.211	.455	.270	.073	.345
MELGLASI	-.434	.188	-.308	.278	.077	.021
MELAMELL	**.784**	**.615**	**.540**	-.054	.003	.065
MELASCAL	-.095	.009	.224	.228	.052	.262
PLATALBI	.364	.132	.389	.153	.023	.315
PLATANGU	**.897**	**.805**	**.701**	-.076	.006	.026
PYROROSA	.644	.415	.597	-.082	.007	-.078
RHINCAMP	.704	.495	.685	.143	.020	.315
SPHASCRI	**.908**	**.824**	**.786**	-.078	.006	.092
SYRPRIBE	.231	.054	.352	.073	.005	.019
XYLOSEGN	-.101	.010	-.163	.649	.421	.203

Probably the hoverfly fauna becomes a more stable fauna which is less divers (lower diversity) and consists mainly of forest species that replace more common and eurytopic species. This seems to be a rather slowly ongoing process. Even after 25 years afforestation and start of plantation, we find only few of the rare forest species and even than in small numbers. Nevertheless when a new forest is planted we can more quickly create a forest vegetation structure with the needed different vegetation strata than is the case in afforestation. Perhaps plantation can speed up changing from agricultural site to forest. In the planted sites a forest fauna was already developed after 20 years, but this fauna is still different from the fauna from the ancient forests. However a forest needs its time to establish a typically forest hoverfly fauna. Many of the larvae of the critical species depend on older trees, thick, softened dead wood and large rot holes. This process needs tens/hundreds of years. Maybe critical aphid hunters need specific species of aphids that appear only after some time. Although plantation can speed up this process we would also plead for a natural forest management, allowing for dead wood, open places in the forest, stands and trees of different ages intermixed and a well developed, broad natural forest edge.

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References

DEKONINCK, W., DESENDER, K., GROOTAERT, P. & MAELFAIT, J.-P., 2005. The effects on arthropods of tree plantation and spontaneous afforestation on former agricultural land near old forests in the Voeren region (Belgium). *Bulletin van het Koninklijk Belgisch Instituut voor Natuurwetenschappen, Entomologie* 75: 221-234.

NJN, 1998. Voorlopige atlas van de Nederlandse zweefvliegen (Syrphidae). EIS-Nederland, Leiden en NJN, 's Graveland, 182 pp.

REEMER, M., 1999. Faunistiek en ecologie van het zweefvliegengenus *Epistrophe* in Nederland (Diptera: Syrphidae). *Nederlandse Faunistische Mededelingen*, 8: 33-65.

REEMER, M., 2000. Zweefvliegenveldgids (Diptera, Syrphidae). Jeugdbondsuitgeverij, Utrecht, 64 pp.

REEMER, M., 2003. Zweefvliegen en veranderd bosbeheer in Nederland (Diptera, Syrphidae). Rapport EIS2003-01, Stichting European Invertebrate Survey – Nederland, Leiden, 25 pp.

SPEIGHT, M.C.D., CASTELLA, E., OBRDLK, P. & BALL, S., 2003. Syrph the Net, the database of European Syrphidae, vol. 39, Syrph the Net publications, Dublin.

SSYMANK, A., 2001. Vegetation und blütenbesuchende Insekten in der Kulturlandschaft. – Pflanzengesellschaften, Blühphänologie, Biotopbindung und Raumnutzung von Schwebfliegen (Diptera, Syrphidae) im Drachenfelser Ländchen sowie Methodenoptimierung und Landschaftsbewertung. – Schriftenreihe für Landschaftspflege und Naturschutz, Heft 64, 513 S., BfN, Bonn Bad-Godesberg, zahlr. Abb, und Tabellen, ISBN 3-7843-3607-8.

VAN DER GOOT, V.S., 1981. De zweefvliegen van Noordwest-Europa en Europees Rusland, in het bijzonder de Benelux. Bibliotheek van de K.N.N.V, 32: 1-274.

VAN VEEN, M.P., 2004. Hoverflies of Northwest Europe. KNNV Publishing, Utrecht, The Netherlands, 254 pp.

VERLINDEN, L. & DECLEER, K., 1987. The hoverflies of Belgium and their Faunistics; uitgave van het KBIN studiedocument, nr. 39, Brussel, 170 pp.

VERLINDEN, L., 1991. Zweefvliegen (Syrphidae). Fauna van België. Koninklijk Belgisch Instituut voor Natuurwetenschappen 39, Brussel, 298 pp.

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